

# An Affective Model of Action Selection for Virtual Humans

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## Abstract

The goal of our work aims at implementing progressively an action selection affective model for virtual humans that should be in the end autonomous, adaptive and sociable. Affect, traditionally distinguished from "cold" cognition, regroups emotions and motivations which are highly intertwined. We present a bottom-up approach by implementing first a motivational model of action selection to obtain motivationally autonomous virtual humans. For the adaptability of virtual humans and completeness of our affective model of action selection, we will define the interactions between motivations and emotions in order to integrate an emotional layer. In order to understand how they affect decision making in virtual humans, the motivations should represent more quantitative aspect of the decision making whereas emotions should be more qualitative one.

## 1 Introduction

One of the main problem to solve, when a motivational decision making for individual virtual humans is designed, is the action selection problem: "how to choose the appropriate behavior at each point in time so as to work towards the satisfaction of the current goal (its most urgent need), paying attention at the same time to the demands and opportunities coming from the environment, and without neglecting, in the long term, the satisfaction of the other active needs" (Cañamero, 2000).

In a bottom-up approach, we decide to implement first a motivational model of action selection because motivations are directly implied in the goal-oriented behaviours. Next we will add an emotional layer for the flexibility and the realism of the behaviours. The emotions stay longer in time than the motivations which need to be satisfied rapidly and can modify and modulate motivations according to Frijda (1995): "emotions alert us to unexpected threats, interruptions, and opportunities".

In this paper, we describe first our motivational model of action selection for virtual humans with his functionalities for the flexibility and the coherence of the decision making. We created a simulated environment for testing the model in real-time. Finally we explain how an emotion layer could be added to obtain an affective model of action selection.

## 2 The motivational model of action selection

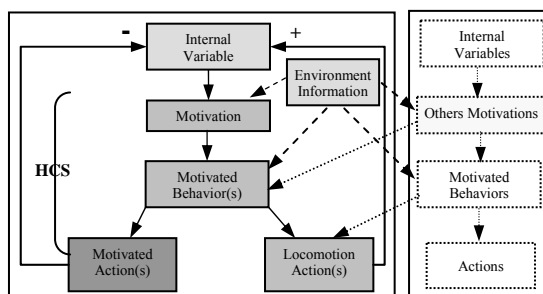


Figure 1: A hierarchical decision graph for one motivation connecting with others decision graphs

Our model is based on hierarchical classifier systems (Donnart and Meyer, 1994) (HCS, one per motivation) working in parallel to obtain goal-oriented behaviors for virtual humans. For the adaptability and reactivity of virtual humans in decision making, the HCS are associated with the functionalities of a free flow hierarchy (Tyrrell, 1993) such as compromise and opportunist behaviors. This model contains four levels per motivation:

- *Internal variables* represent the internal state of the virtual human and evolve according to the effects of actions.

- *Motivations* correspond to a “subjective evaluation” of the internal variables and environment information due to a threshold system and a hysteresis.

- *Motivated behaviors* represent sequences of locomotion actions, generated thanks to the hierarchical classifier system, to reach locations where the virtual human should go to satisfy motivations.

- *Actions* are separated into two types. *Locomotion actions* are only used for moving the virtual human to a specific place, where *motivated actions* can satisfy one or several motivations. Both have a retro-action on internal variable(s). Locomotion actions increase them, whereas motivated actions decrease them.

The motivational model is composed of many hierarchical classifier systems running in parallel. The number of motivations is not limited. Selection of the most activated node is not carried out at each layer, as in classical hierarchy, but only in the end, as in a free flow hierarchy (the action layer). Finally the action chosen is the most activated permitting flexibility and reactivity in decision making of virtual human.

## 2.1 Evaluation of motivations

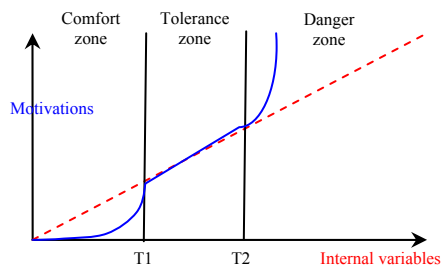


Figure 2: “Subjective” evaluation of one motivation from the values of the internal variable.

The “subjective evaluation” of motivations corresponds to a non-linear model of motivation evolution. A threshold system, specific to each motivation, reduces or enhances the motivation values, according to the internal variable values. This can be assimilated with levels of attention which limit and select information to reduce the complexity of the decision making task (Bryson, 2002). It helps the action selection mechanism to choose the most appropriate behavior at any time.

$$\begin{cases} M = T_1 e^{(i-T_1)^2} & \text{if } i < T_1 \\ M = i & \text{if } T_1 \leq i \leq T_2 \\ M = \frac{i}{(1-i)^2} & \text{if } i > T_2 \end{cases}$$

where  $M$  is the motivation value,  $T_1$  the first threshold and  $i$  the internal variable

If the internal variable lies beneath the threshold  $T_1$  (comfort zone), the virtual human doesn’t take the motivation into account. If the internal variable is beyond the second threshold  $T_2$  (danger zone), the value of the motivation is amplified in comparison with the internal variable. In this case, the corresponding action has more chances to be chosen by the action selection mechanism, to decrease the internal variable.

Moreover a hysteresis has been implemented, specific to each motivation, to keep at each step a portion of the motivation from the previous iteration, therefore permitting the persistence of motivated actions:

$$M_t = (1 - \alpha) \cdot M_{t-1} + \alpha(M + e_t)$$

where  $M_t$  is the motivation value at the current time,  $M$  the “subjective” evaluation of the motivation,  $e_t$  the environment variable and  $\alpha$  the hysteresis value with  $0 \leq \alpha \leq 1$ .

The hysteresis maintain the activity of the motivations and the corresponding motivated actions for a while, even though the activity of internal variables decreases. Indeed, the chosen action must remain the most activated until the internal variables have returned within their comfort zone. The hysteresis limits the risk of action selection oscillations between motivations and permits the persistence of motivated actions and the coherence in decision making.

## 2.2 Behavioral planner

To reach the specific locations where the virtual human can satisfy his motivations, goal-oriented behaviors (sequences of locomotion actions) need to be generated, according to environment information and internal context of the hierarchical classifier system. It can be use also for the complex actions as cooking which need to follow order in the sequence of actions. Moreover a learning or evolution process can be implemented thanks to weights of classifiers to optimize behaviors.

Time steps	t0	t1	t2	t3	t4	t5	t6
Environment information	known food location, but remote				Near food	Food near mouth	No food
Internal context (Message List)	hunger						
			reach food location				
Actions				Go to food	Take food	Eat	
Activated rules		R0	R1	R2	R3	R4	

Table 1: Simple example for generating a sequence of action using a hierarchical classifier system.

In the example (table 1), hunger is the highest motivation and must remain so until the nutritional state is returned within the comfort zone. The behavioral sequence of actions for eating needs two internal classifiers (modifying internal context):

**R0**: if known food location and the nutritional state is high, then hunger.

**R1**: if known food is remote and hunger, then reach food location.

and three external classifiers (activating actions):

**R2**: if reach food location and known food is remote, then go to food.

**R3**: if near food and reach food location, then take food.

**R4**: if food near mouth and hunger, then eat.

Here, the virtual human should go to a known food location where he can satisfy his hunger, but needs to generate a sequence of locomotion actions to reach that place. In this case, two internal messages “hunger” and “reach food location” are added to the message list, thanks to the internal classifiers R0, then R1. They represent the internal state for the rules and remain until they are realized. To reach the known food location, two external classifiers (R2 and R3) activate locomotion actions (as many times as necessary). When the virtual human is near the food, the internal message “reach food location” is deleted from the message list and the last external classifier R4 activates the motivated action “eat”, decreasing the nutritional state. Thereafter the internal message “hunger” is deleted from the message list, the food has been eaten and the nutritional state is returned within the comfort zone for a while.

### 2.3 Reactive architecture

As activity is propagated throughout the model according to the free flow hierarchy, and the choice is only made at the level of actions, the most activated action is chosen according to motivations and environment information. A greater flexibility and reactivity in the behavior, such as compromise and opportunist behaviors are then possible in spite of behavioral planner.

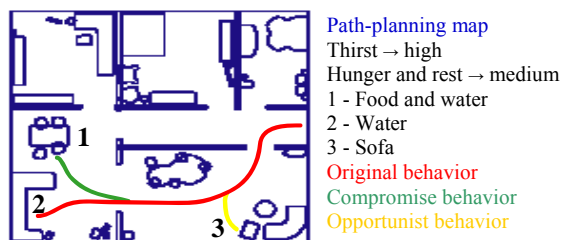


Figure 3: Compromise behavior (green): the virtual human goes where he can eat and drink instead of just drinking. Opportunist behavior (yellow): he stops to rest when he sees the sofa.

Compromise behaviors have more chances of being chosen by the action selection mechanism,

since they can group activities coming from several motivations and can satisfy them at the same time. Opportunist behaviors occur when the virtual human perceives objects that can satisfy his motivations. These motivations are proportionally increased compared to the distance between objects and the virtual human. For these two behaviors, the propagated value in the model can be modified at two levels: at the motivations and motivated behaviors levels (see figure 1). If the current behaviour is exceeded, it is interrupted and a new sequence of locomotion actions is generated in order to reach the location where he can satisfy the new motivation.

### 3 Testing the model in a simulated environment

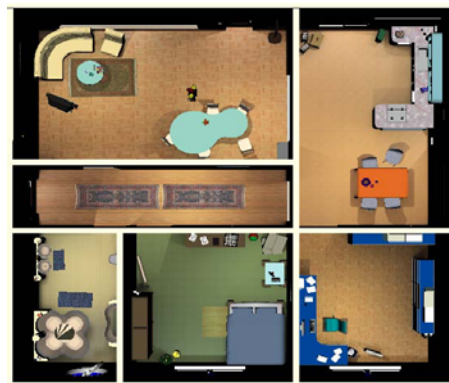


Figure 4: Top view of the simulated environment (apartment) in the 3D viewer.

We choose to simulate a virtual human in an apartment where he can “live” autonomously by perceiving his environment and satisfying several motivations. We arbitrarily define fourteen conflicting motivations (the number is not limited) that a human can have in this environment with their specific locations and the associated motivated actions.

motivations	locations	action
hunger	table	eat
thirst	sink, table	drink
toilet	toilet	satisfy
resting	sofa	rest
sleeping	bed	sleep
washing	bath	wash
cooking	oven	cook
cleaning	worktop, shelf	clean
reading	bookshelf	read
communicating	computer, phone	communicate
exercise	living, hall, room	do push-up
watering	plant	water
Watching (default)	sofa	watch TV
...	...	...

Table 2: all available motivations with associated actions and their locations.

At any time, the virtual human has to choose the most appropriate action to satisfy the highest motivation between conflicting ones according to environmental information. Then he goes to the specific place in the apartment where he can satisfy this motivation. Compromise behaviors are possible, for example the virtual human can drink and eat at the table. However he can perform different actions in the same place but not at the same time. The virtual human can also perform the same action in different places: for example clean at the worktop or at the shelf. Moreover he has a perception system to permit opportunist behaviors. The default action is watching television in the living room.

The users can add new motivations at the beginning, change all the parameters and monitor the different model level during the simulation.

## 4 Concluding remarks

The test application simulates in a 3D graphics engine (Ponder, 2003) a virtual human in an apartment, making decisions using the motivational model according to the motivations and the environment information. As a whole the action selection architecture doesn't oscillate between several motivations, managing the fourteen conflicting motivations, thanks to the hysteresis and the behavioral planner, and have also reactive behaviors such as compromise and opportunist behaviors. In the end the virtual human "lives" autonomously and adaptively in his apartment. Furthermore, the number of motivations in the model is not limited and can easily be extended.

The model has some limitations, though. For the time being, each motivation has the same importance in the decision-making process, although we know that some motivations are more important than others in real life. Here, the virtual human also always carries out the most activated action in any case. However, some actions should sometimes be delayed according to context.

## 5 Future work

Integrating emotions in the motivational model of action selection can reduce these limitations. First we plan to define the interactions between motivations, emotions and personalities to understand how they affect decision making in virtual humans. The main problem is to connect the emotional layer with the rest of the architecture. It could be made by a sort of synthetic physiology (Avila-Garcia and Cañamero, 2004). The motivations should be more quantitative aspect of the decision making whereas emotions should be the more qualitative one. The low level part of the architecture should be more

automatic whereas the high level part should be more specified in real time by the users. The emotions will be independent from the motivations but influence them at the level of length, perception, activation and interruption. In the end we plan also to manage basic social interactions by adding another virtual humans in the apartment or/and by interacting directly with virtual reality devices in the next future.

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